Revised 4/15/2021

FIN WHALE (*Balaenoptera physalus velifera*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Fin whales are found from temperate to subpolar oceans worldwide, with a distributional hiatus between the Northern and Southern Hemispheres within 20° to 30° of the equator (Edwards *et al*. 2015).). Fin whales occur throughout the North Pacific, from the northeastern Chukchi Sea (Crance *et al.* 2015) to the Tropic of Cancer (Mizroch *et al.* 2009), but their wintering areas are poorly known. Archer *et al*. (2019a) used mitochondrial DNA and single-nucleotide polymorphisms (SNPs) to demonstrate that North Atlantic and North Pacific genetic samples could be correctly assigned to their respective ocean basins with 99% accuracy. North Pacific fin whales are recognized as a separate subspecies: *Balaenoptera physalus velifera*. Mizroch *et al.* (2009) described eastern and western North Pacific populations, based on sightings data, catch statistics, recaptures of marked whales, blood chemistry, and acoustics. The two populations are thought to have separate wintering and mating grounds off Asia and North America and during summer, whales from each population may co-occur near the Aleutian Islands and Bering Sea (Mizroch *et al.* 2009). Non-migratory populations exist in the Gulf of California, based on evidence from photo-ID, genetics, satellite telemetry, and acoustics (Thompson *et al*. 1992; Tershy *et al.* 1993; Bérubé *et al.* 2002; Jiménez López *et al*. 2019; Nigenda-Morales 2008; Širović *et al*. 2017) and the East China Sea (Fujino 1960). Fin whales are scarce in the eastern tropical Pacific in summer (Wade and Gerrodette 1993) and winter (Lee 1993). Fin whales occur year-round in the Gulf of Alaska (Stafford *et al.* 2007); the Gulf of California (Tershy *et al.* 1993; Bérubé *et al.* 2002); California (Dohl *et al.* 1983; Širović *et al*. 2017); and Oregon and Washington (Moore *et al.* 1998). Fin whales satellite-tagged in the Southern California Bight (SCB) use the region year-round, although they seasonally range to central California and Baja California before returning to the SCB (Falcone and Schorr 2013). The longest satellite track reported by Falcone and Schorr (2013) was a fin whaletagged in the SCB in January 2014. The whale moving south to central Baja California by February and north to the Monterey area by late June. Archer *et al.* (2013) present evidence for geographic separation of fin whale mtDNA clades near Point Conception, California. A significantly higher proportion of 'clade A' is composed of samples from the SCB and Baja California, while 'clade C' is largely represented by samples from central California, Oregon, Washington, and the Gulf of Alaska.

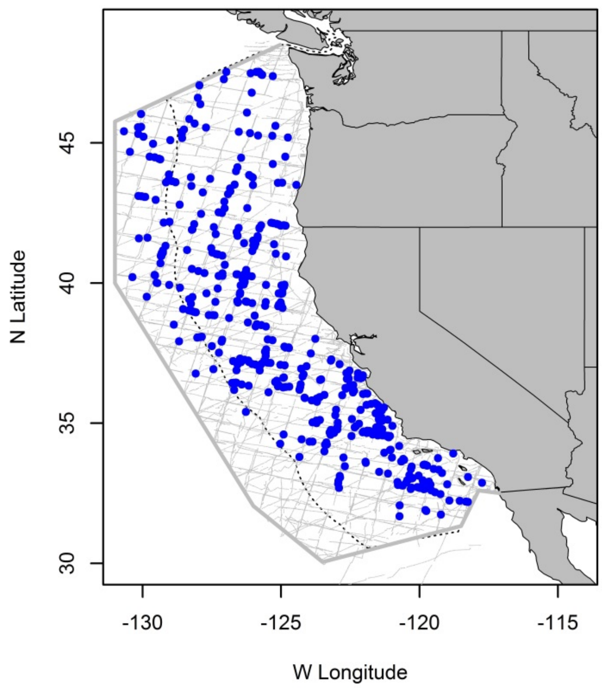

Figure 1. Fin whale sighting locations based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ; thin lines indicate completed transect effort of all surveys combined.

While knowledge of North Pacific fin whale population structure from genetic and movement patterns is limited, passive acoustic data provides another line of evidence to assess population structure. For example, acoustic data (Širović *et al*., 2017; Thompson *et al*., 1992) support prior photo-ID (Tershy *et al.* 1993) and genetic conclusions (Bérubé *et al.* 2002; Nigenda-Morales *et al.* 2008; Rivera-León *et al.* 2019) that a resident fin whale population occurs in the Gulf of California, Mexico. Additionally, acoustic data indicate there may be a resident population in southern California waters, though this may be confounded by seasonal movements in the region (Širović *et al*., 2015, 2017). Oleson *et al*. (2014) report that fin whale songs recorded near Hawaii are similar to those from southern California and the Bering Sea, suggesting movement of animals throughout that range. Song structure throughout the North Pacific is characterized by seasonal and interannual variability (Delarue *et al*., 2013; Oleson *et al*., 2014; Širovic *et al*., 2017; Weirathmueller *et al*., 2017). Similarities of songs within and across years for multiple North Pacific pelagic areas (Hawaii, Bering Sea, Southern California) suggests that a single population may range throughout this oceanic basin; however there is also evidence for multiple song types in the Bering Sea (Delarue *et al*., 2013) and the northeast Pacific, including a possible resident population in inland waters of British Columbia (Koot, 2015). Archer *et al*. (2019b) developed an automated classification method for fin whale note types that revealed analysts have manually misclassified certain fin whale note types near Hawaii, which has implications for stock identification interpretation. These authors found that Hawaii had some of the most distinctive calls, with sequences characterized by "B" type calls with relatively long internote intervals. Archer *et al*. (2019b) also notes the similarity of B sequences from the Gulf of California in spring that match those described by Širović *et al*. (2017) as a "long singlet" pattern found in the southern Gulf of California and southern California Bight. In the Archer *et al*. (2019b) study, the B singlet pattern was most similar to Monterey Bay and northwest Pacific autumn sequences, perhaps reflecting a widespread pattern across populations in the North Pacific, or hinting at some population connectivity between the central and southern U.S. West Coast and southern Gulf of California and the northwest Pacific (Archer *et al*. 2019b). Acoustic evidence also hints at possibly two populations that use the Chuckchi Sea and central Aleutian Islands area that mix seasonally in the southern Bering Sea (Archer *et al*. 2019b). Observed movements of fin whales from the southern and central Bering Sea to the Aleutian Islands and Kamchatka documented from Discovery tag recoveries are consistent with these acoustic findings (Mizroch *et al*. 2009). Further research is necessary to use multiple lines of evidence, such as acoustics, genetics, and satellite telemetry in order to identify population stocks in the North Pacific (Martien *et al.* 2020).

Insufficient data exists to determine population structure, but from a conservation perspective it may be risky to assume panmixia in the North Pacific. This report covers the stock of fin whales found along the coasts of California, Oregon, and Washington within 300 nmi of shore (Fig. 1). Because fin whale abundance appears lower in winter/spring in California (Dohl *et al.* 1983; Forney *et al.* 1995) and in Oregon (Green *et al.* 1992), it is likely that the distribution of this stock extends seasonally outside these coastal waters. The Marine Mammal Protection Act (MMPA) stock assessment reports recognize three stocks of fin whales in the North Pacific: (1) the California/Oregon/Washington stock (this report), (2) the Hawaii stock, and (3) the Northeast Pacific stock.

POPULATION SIZE

The pre-whaling population of fin whales in the North Pacific was estimated to be 42,000-45,000 (Ohsumi and Wada 1974). In 1973, the North Pacific population was estimated to have been reduced to 13,620-18,680 (Ohsumi and Wada 1974), of which 8,520-10,970 were estimated to belong to the eastern Pacific stock. The best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nmi is 9,029 (CV=0.12) whales, based on a trend analysis of 1991-2014 line-transect data (Nadeem *et al.* 2016; Fig. 2). This estimate is based on similar methods applied to this population by Moore and Barlow (2011). However, the new abundance estimate is significantly higher than earlier estimates because the new analysis incorporates lower estimates of *g(0)*, the trackline detection probability (Barlow 2015). The trend-model analysis incorporates information from the entire 1991-2014 time series for each annual estimate of abundance, and given the strong evidence of an increasing abundance trend over that time (Moore and Barlow 2011, Nadeem *et al.* 2016), the best estimate of abundance is represented by the estimate for the most recent year, or 2014. This is probably an underestimate because it excludes some fin whales that could not be identified in the field and were recorded as "unidentified rorqual" or "unidentified large whale".

Minimum Population Estimate

The minimum population estimate for fin whales is taken as the lower 20th percentile of the posterior distribution of 2014 abundance estimate, or 8,127 whales.

Current Population Trend

Indications of recovery in CA coastal waters date back to 1979/80 (Barlow 1994), but there is now strong evidence that fin whale abundance increased in the California Current between 1991 and 2008 based on analysis of line transect surveys conducted in the California Current between 1991 and 2014 (Nadeem *et al.* 2016, Fig. 2). Abundance in waters out to 300 nmi off the coast of California approximately doubled between 1991 and 1993, from approximately 1,744 (CV = 0.25) to 3,369 (CV= 0.21), suggesting probable immigration of animals into the area. Across the entire study area (waters off California, Oregon, and Washington), the mean annual abundance increase was 7.5%, although abundance appeared stable between 2008 and 2014. In all, there has been a roughly 5-fold abundance increase between 1991 and 2014. Since 2005, the abundance increase has been driven by increases off northern California, Oregon and Washington, while numbers off Central and Southern California have been stable (Nadeem *et al.* 2016). Zerbini *et al.* (2006) found similar evidence of increasing fin whale abundance in Alaskan waters at a rate of 4.8% annually between 2001 and 2003.

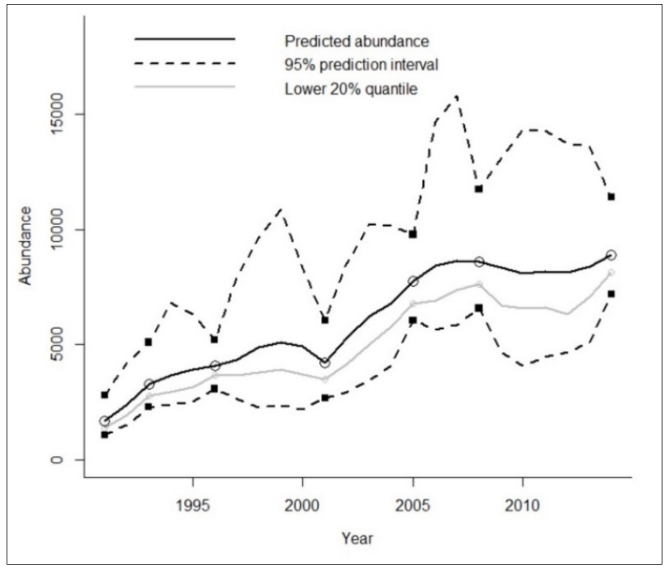

Figure 2. Trend-based estimates of fin whale abundance, 1991- 2014, with 95% Bayesian credible intervals (Nadeem *et al*. 2016).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Estimated annual rates of increase in the California Current (California, Oregon, and Washington waters) averaged 7.5% from 1991 to 2014 (Nadeem *et al.* 2016). However, it is unknown how much of this growth is due to immigration rather than birth and death processes. A doubling of the abundance estimate in California waters between 1991 and 1993 cannot be explained by birth and death processes alone, and movement of individuals between U.S. west coast waters and other areas (e.g., Alaska, Mexico) have been documented (Mizroch *et al.* 1984).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (8,127) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for an endangered species, with $N_{min} >$ 5,000 and $CV_{Nmin} < 0.50$, Taylor *et al.* 2003), resulting in a PBR of 81 whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

The California large-mesh drift gillnet fishery for swordfish and thresher shark includes one observed entanglement record (in 1999) of a fin whale from 9,085 observed fishing sets during 1990 - 2018 (Carretta 2020). The estimated bycatch of fin whales in this fishery for the most recent 5-year period is zero whales (Carretta 2020).

In addition to drift gillnets, fin whales are observed entangled in longline gear. One fin whale was observed entangled in 2015 in the Hawaii shallow-set longline fishery in waters between the U.S. West Coast and Hawaiian EEZs. The entanglement was assigned a non-serious injury, based on the animal being cut free of the gear with superficial wounds caused by the line (Bradford 2018). The stock identity of this whale is unknown.

Three fin whale serious injuries were documented in unidentified fishing gear during 2014-2018, or 0.6 whales annually (Carretta *et al.* 2020). Additionally, there were 21 *unidentfied whale* entanglements during this period, of which, 0.46 were prorated as fin whales using the method reported by Carretta (2018). Unidentified whale entanglements typically involve whales seen at-sea with unknown gear configurations that are prorated to represent 0.75 serious injuries per entanglement case. Thus, approximately 0.46 x 0.75 = 0.35 fin whale serious injuries occurred from the 21 unidentified whale entanglement cases during 2014-2018 (Table 1). This represents a negligible annual estimate of 0.07 prorated fin whales derived from sightings of unidentified entangled whales. Total mean annual fishery-related serious injury and mortality is the sum of observed (0.6) and prorated (0.07) mean annual deaths and serious injuries, or 0.67 fin whales annually (Table 1).

Table 1. Summary of available information on the incidental mortality and serious injury of fin whales (CA/OR/WA stock) for commercial fisheries that might take this species. .

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed (or self-reported)	Estimated Mortality (and serious injury)	Mean Annual Mortality and Serious Injury (CV in parentheses)
CA swordfish and thresher shark drift gillnet fishery	2014-2018	observer	21%	0	0 (n/a)	0 (n/a)
Unidentified fishery interactions involving *fin whales*	2014-2018	at-sea sightings	n/a	3	0 (3)	≥ 0.6
Unidentified fishery interactions involving *unidentified whales* prorated to fin whale	2014-2018	at-sea sightings	n/a	n/a	0 (0.35)	0.07
Minimum total annual takes						≥ 0.67 (n/a)

Ship Strikes

Ship strikes were implicated in the deaths of 8 fin whales from 2014-2018 (Carretta *et al.* 2020). Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. The average observed annual mortality and serious injury due to ship strikes is 1.6 fin whales per year during 2014-2018. Documented ship strike deaths and serious injuries are derived from direct counts of whale carcasses and represent minimum impacts. Where evaluated, estimates of detection rates of cetacean carcasses are consistently low across different regions and species (<1% to 33%), highlighting that observed numbers underestimate true impacts (Carretta *et al.* 2016, Kraus *et al.* 2005, Williams *et al.* 2011, Prado *et al.* 2013, Wells *et al.* 2015). Ship strike mortality was recently estimated for fin whales in the U.S. West Coast EEZ (Rockwood *et al.* 2017), using an encounter theory model (Martin *et al.* 2016) that combined species distribution models of whale density (Becker *et al.* 2016), vessel traffic characteristics (size + speed + spatial use), along with whale movement patterns obtained from satellite-tagged animals to estimate encounters that would result in mortality. The estimated number of annual ship strike deaths was 43 fin whales, though this includes only the period July – November when whales are most likely to be present in the U.S. West Coast EEZ and the season that overlaps with cetacean habitat models generated from line-transect surveys (Becker *et al.* 2016, Rockwood *et al.* 2017). This estimate is based on an assumption of a moderate level of vessel avoidance (55%) by fin whales, as measured by the behavior of satellite-tagged *blue whales* in the presence of vessels (McKenna *et al.* 2015). The estimated mortality of 43 fin whales annually due to ship strikes represents approximately < 0.5% of the estimated population size (43 deaths / 9,029 whales). The results of Rockwood *et al.* (2017) also include a no-avoidance encounter model that results in a worst-case estimate of 95 fin whale ship strike deaths per year, representing approximately 1% of the estimated population size. The authors also note that 65% of fin whale ship strike mortalities occur within 10% of the study area, implying that vessel avoidance mitigation measures can be effective if applied over relatively small regions. The authors of Rockwood *et al.* (2017) also estimated a worst-case ship strike carcass recovery rate of 5% for fin whales, but this estimate was based on a multispecies average from three species (gray, killer and sperm whales). Another way to estimate carcass recovery and/or documentation rates of fin whales killed or seriously injured by vessels is by directly comparing the documented number of ship strike deaths and serious injuries with annual estimates of vessel strikes from Rockwood *et al.* (2017). Comprehensive coast-wide data on ship strike deaths and serious injuries assumed to result in death are compiled in annual reports on observed anthropogenic morality for the 12-year period 2007-2018 (Carretta *et al.* 2013, 2018, 2020). During this 12-year period, there were 20 observations of fin whale ship strike deaths and 1 serious injury assumed to result in the death of the whale, or 1.8 fin whales annually. The most conservative estimate of ship strike deaths from Rockwood *et al.* (2017) is 43 whales annually. The ratio of documented ship strike deaths (1.8/yr) to estimated annual deaths (43) implies a carcass recovery/documentation rate of 4.1%, which is lower than the worst-case estimate of 5% from Rockwood *et al.* (2017). There is uncertainty regarding the estimated number of ship strike deaths, however, it is apparent that carcass recovery rates of fin whales are quite low.

Vessel traffic within the U.S. West Coast EEZ continues to be a ship strike threat to all large whale populations (Redfern *et al*. 2013, Moore *et al.* 2018). However, a complex of vessel types, speeds, and destination ports all contribute to variability in ship traffic, and these factors may be influenced by economic and regulatory changes. For example, Moore *et al*. (2018) found that primary vessel travel routes changed when emission control areas (ECAs) were established off the U.S. West Coast. They also found that large vessels typically reduced their speed by 3-6 kts in ECAs between 2008 and 2015. The speed reductions are thought to be a strategy to reduce operating costs associated with more expensive, cleaner burning fuels required within the ECAs. In contrast, Moore *et al*. (2018) noted that some vessels increased their speed when they transited longer routes to avoid the ECAs. Further research is necessary to understand how variability in vessel traffic affects ship strike risk and mitigation strategies.

STATUS OF STOCK

Fin whales in the North Pacific were given protected status by the IWC in 1976. Fin whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently this stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The total observed incidental mortality and serious injury (2.5/yr), due to fisheries (0.67/yr, including identified and prorated fin whales), and ship strikes (1.8/yr), is less than the calculated PBR (81). However, observations alone underestimate true impacts due to incomplete detection of vessel strikes and fishery entanglements. Total fishery mortality is less than 10% of PBR and, therefore, may be approaching zero mortality and serious injury rate.

Estimated vessel strike mortality is 43 whales annually, or approximately 0.5% of the estimated population size. As these estimates are model-derived, they are inherently corrected for undocumented and undetected cases, but they represent only a portion of the year (July-December) for which habitat model data are available. The worst-case vessel strike estimate of mortality is 95 whales, based on no avoidance of vessels, or approximately 1% of the estimated population size. Neither vessel strike estimate includes incidents outside of the U.S. West Coast EEZ.

There is strong evidence that the population has increased since 1991 (Moore and Barlow 2011, Nadeem *et al.* 2016). Increasing levels of anthropogenic sound in the world's oceans is a habitat concern for whales, particularly for baleen whales that communicate using low-frequency sound (Croll *et al.* 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged *blue* whales (Goldbogen *et al.* 2013), but it is unknown if fin whales respond in the same manner to such sounds.

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